PREDICTING LANDING SOLUTIONS FOR A ROCKET IN A TWO-BODY SYSTEM

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Motivation for Research

- Can we obtain a reliable curve fit to show direct relationships between parameters for a model?
- Expanded upon a case study for landing a rocket on the lunar surface.

Edwards, C. Henry, and David E. Penney. *Differential Equations & Boundary Value Problems Computing and Modeling*. 4th ed. Upper Saddle River: Pearson Custom, 2008. Print.

Tools

- Numerical method: 4^{th} order Runge-Kutta (RK4)
  - Considered an accurate method for integrating differential equations.
  - RK4 calculates a weighted average slope from four points.
- Programming language: C++
  - C++ automated the RK4 process.
- Plots & Graphs: Microsoft Excel
  - Excel used to apply the best-fit curves.

Scenario

System of Equations:

Position: $r(t)$ for $r(0) = 1{,}781{,}870$

Velocity: $\frac{dr_1}{dt} = v(t)$ for $v(0) = -450$

Acceleration: $\frac{dr_2}{dt} = \frac{dv}{dt} = T - \frac{GM}{r^2}$

Constants:

Deceleration from thrust: T = 4 m/s^2

Gravitational constant: G = 6.6726 x 10^{-11} $N*m^2/kg^2$

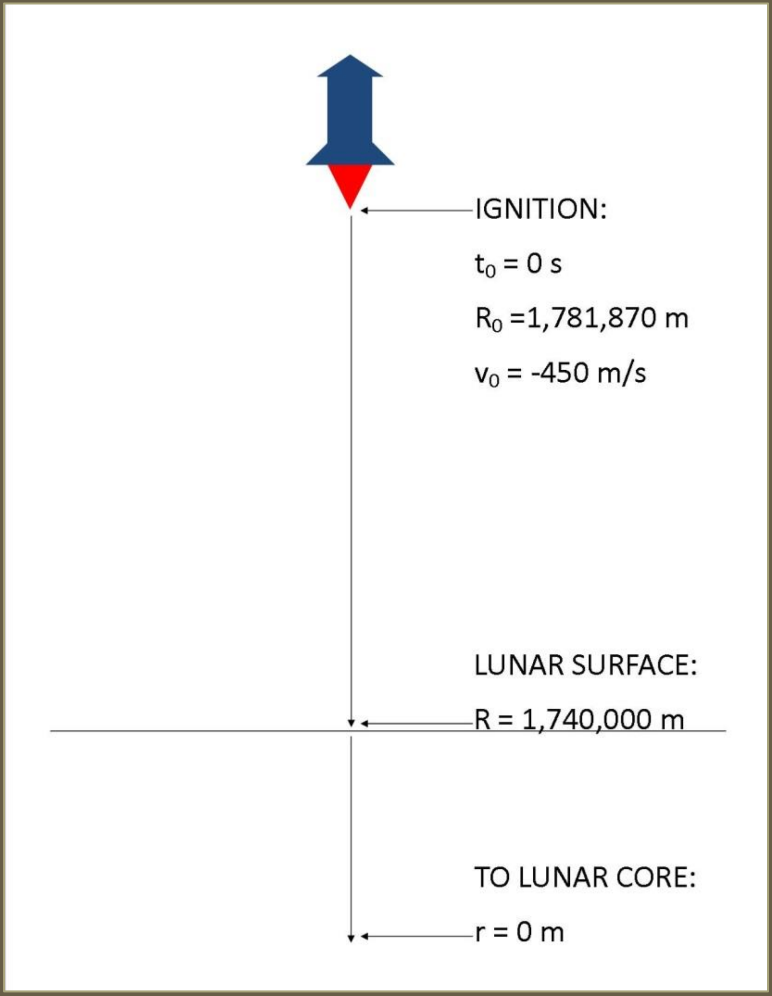
Lunar mass: M = 7.35 x 10^{22} kg

Additional Inputs:

Upper limit of integration: t_n = 200 s

Number of steps: n = 200

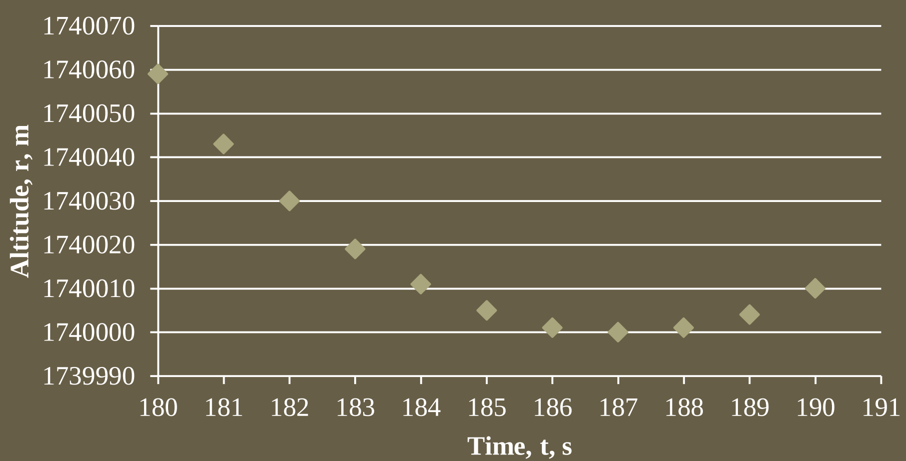
Step size: h = 1 s



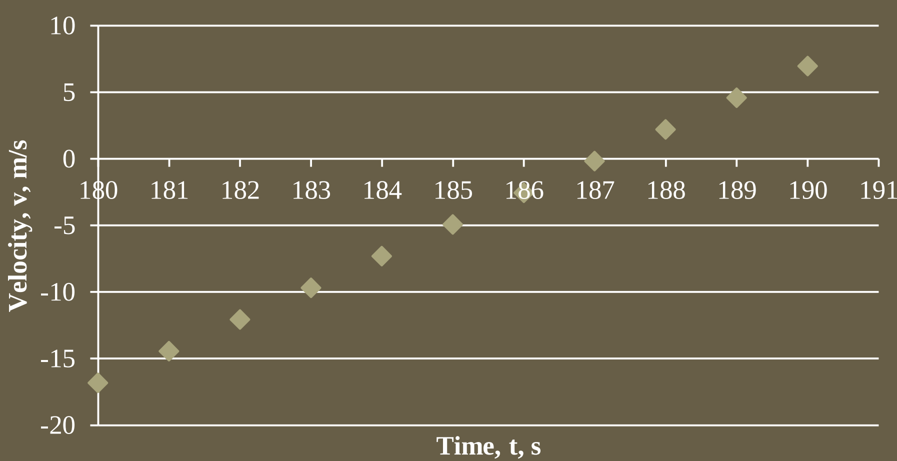
Case Study Results

Time	Case Study Altitude	Simulation Altitude	Case Study Velocity	Simulation Velocity
180	1740059	1740059	-16.83	-16.83
181	1740044	1740043	-14.45	-14.45
182	1740030	1740030	-12.07	-12.07
183	1740019	1740019	-9.69	-9.69
184	1740011	1740011	-7.31	-7.31
185	1740005	1740005	-4.93	-4.93
186	1740001	1740001	-2.55	-2.55
187	1740000	1740000	-0.17	-0.17
188	1740001	1740001	2.21	2.21
189	1740004	1740004	4.59	4.59
190	1740010	1740010	6.97	6.97

Altitude Vs. Landing Time

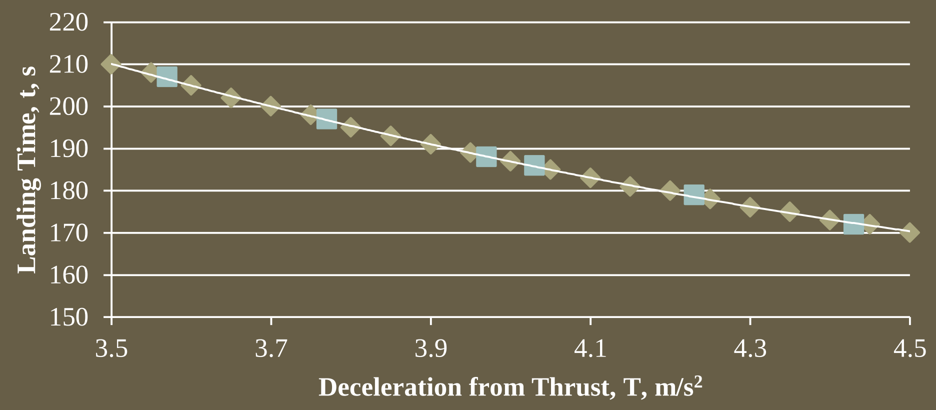


Velocity Vs. Landing Time

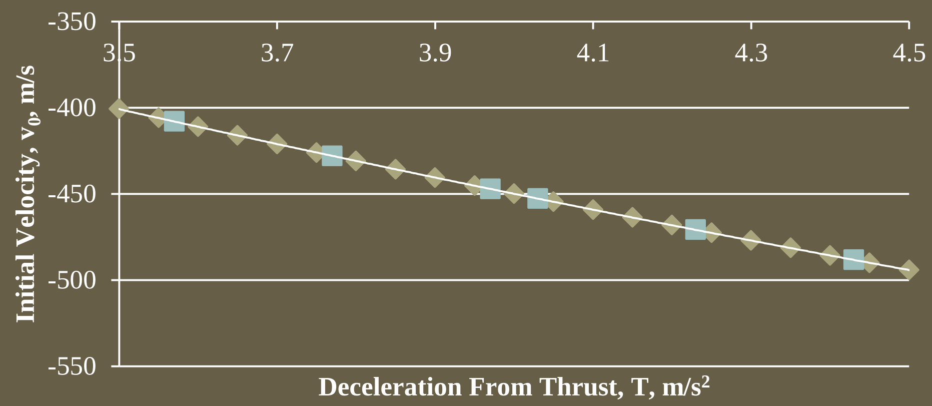


Interpolation

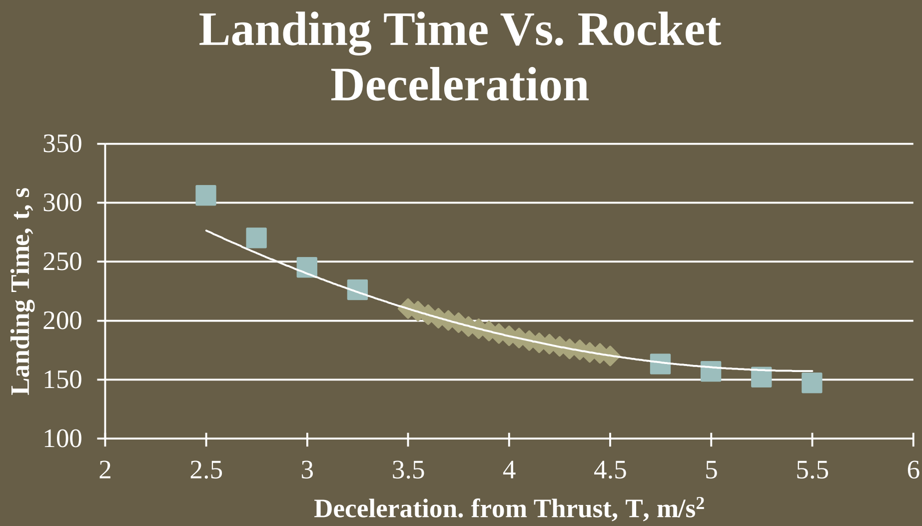
Landing Time Vs. Rocket Deceleration

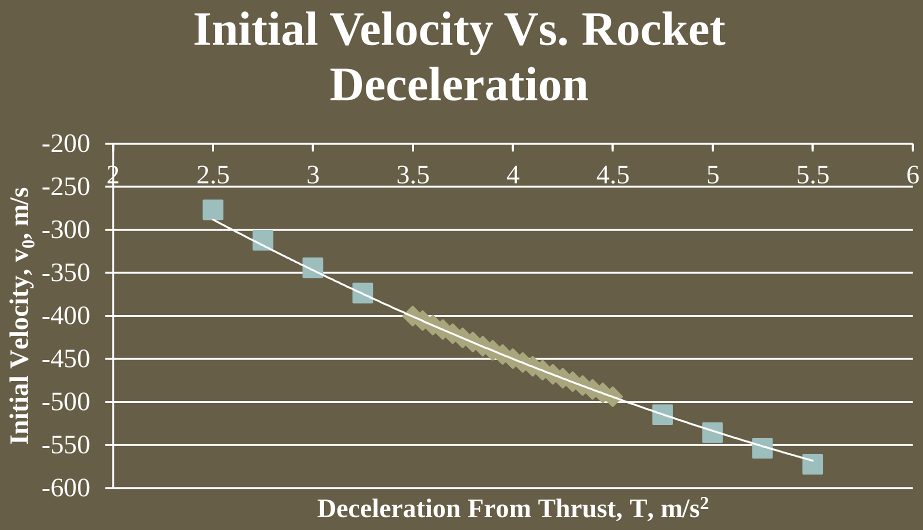


Initial Velocity Vs. Rocket Deceleration



Extrapolation





Results

- Choose a domain so all the estimations are interpolations.
- Avoid curve fits with changes in concavity.

Future Investigations:

- Examine data using a different independent variable.
- Increase the model's complexity to investigate the relationships between a larger number of parameters.